PROCEEDINGS OF THE BIOLOGICAL SOCIETY OF WASHINGTON
116(1):215–221. 2003.

Description of subadult *Pallisentis* (*Pallisentis*) *rexus* (Acanthocephala: Quadrigyridae) from the vertebrate intermediate host in Thailand with an examination of the species identity

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Abstract.—Subadults (considerably developed immatures) of the quadrigyrid acanthocephalan *Pallisentis rexus* Wongkham & Whitfield, 1999 are described from the swamp eel, *Monopterus albus* (Zieuw, 1793) in Thailand. The species is placed in the subgenus *Pallisentis.* Our specimens are compared with adults of the same species collected from the freshwater snakehead *Ophicephalus striata* Bloch also from Thailand. Discrepancies from the original description are noted, certain structures, e.g., proboscis hook roots and brain (cepahalic ganglion), are re-interpreted, and additional information provided.

The genus *Pallisentis* Van Cleave, 1928 was revised, three subgenera were erected, and a key to the valid species, and other taxonomic information were provided by Amin et al. (2000). About the same time, Wongkham & Whitfield (1999) described *Pallisentis rexus* from the freshwater snakehead, *Ophicephalus striata* Bloch, from the Chiang Mai Basin in Thailand. More recently, we have collected subadults of *P. rexus* from the swamp eel, *Monopterus albus* (Zieuw, 1793) from Bangkok, Thailand. Our specimens and type material examined by us shed considerably more light on the morphology and status of *P. rexus* which the present study reports in a comparative context.

Materials and Methods

Ten 40–80 cm long swamp eels, *M. albus,* were examined for parasites on 20 March 2001. The fish, obtained from a fish market in Bangkok, Thailand, had been collected from local streams. The 10 fish were infected with a total of 257 (range 5–74 per fish) ovoid whitish nodules in the body cavity especially at the external surface of the hind gut. The encapsulated worms were mostly alive when liberated from their cysts in fish physiological solution. Forty-two worms (16 males, 26 females) were refrigerated in tap water overnight then fixed and shipped in 5% formalin. They were subsequently transferred to 70% ethanol, stained in Mayer's acid carmine overnight then briefly destained, dehydrated in ascending concentrations of ethanol, cleared in graduated concentrations of terpineol in 100% ethanol, and whole mounted in Canada balsam.

Measurements are in μm unless otherwise stated. The range is followed by mean values (in parentheses). Width measurements refer to maximum width. Trunk length does not include proboscis, neck, or male bursa. The term subadults is used to describe the highly developed immature forms. They are practically identical to adults; all males and females were distended with sperm and ovarian balls, respectively. Specimens were deposited in the United States National Parasite Collection (USNPC) no. 91753. Beltsville, Maryland, U.S.A. Seven adult paratypes (3 males, 4 females) from the British Museum of Natural History (BMNH) (no. 1997.6.3.2-13) were also studied.

Results and Discussion

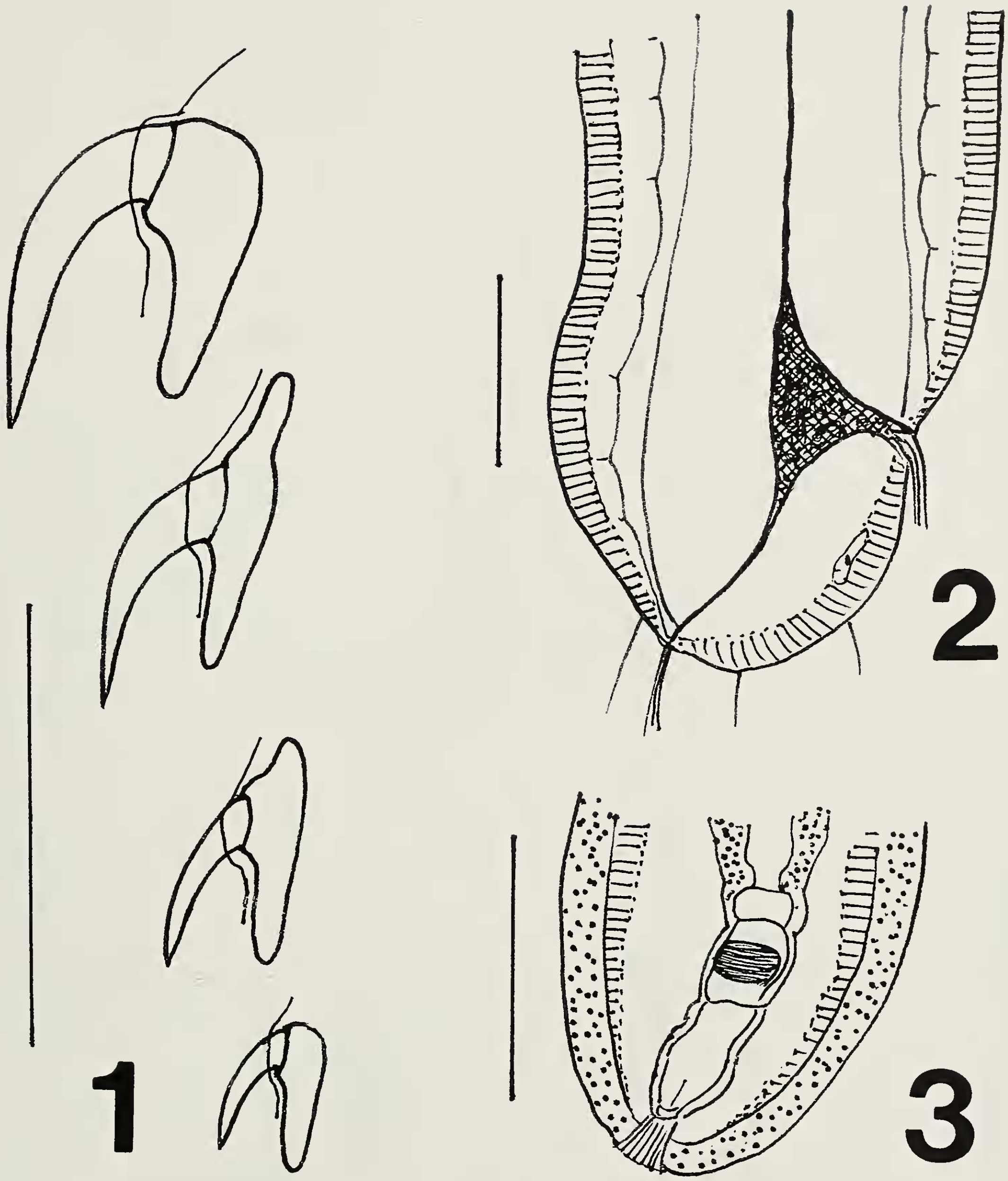
It is important to note that all characteristics of our *P.* (*P.*) *rexus* subadults listed in Table 1 and illustrated in Figures 1–3 match those observed in the adult paratypes borrowed from BMNH. The anatomy of the subadults is generally similar to that of the adults as described by Wongkham & Whitfield (1999). However, misinterpretations and omissions exist in the original description which otherwise was adequate. The quality of staining of paratypes produced faded and often indistinguishable structures, e.g., proboscis hook roots and cephalic ganglia, which readily explains Wongkham & Whitfield's (1999) version of worm anatomy. We shall report these discrepancies in the following section in an attempt to provide an accurate and complete description of the species.

Pallisentis rexus is placed in the subgenus *Pallisentis* according to Amin et al. (2000) because the proboscis hooks gradually decline in size posteriorly and the cement glands are long and with many giant nuclei.

Qualitative and quantitive traits of *P.* (*P.*) *rexus* subadults are provided and compared with those of adults, when available (Table 1). Measurements of subadults largely fell within the range of those reported for adults by Wongkham & Whitfield (1999). On the average, subadults, especially females, were relatively smaller than adults in only one character, trunk length. However, mean size of proboscis, proboscis hooks, proboscis receptacle, and lemnisci were somewhat greater in subadults than in adults. This observation is attributed to two factors: the apparent precocious state of development of subadult *P.* (*P.*) *rexus* (with sperm and ovarian balls) in their vertebrate intermediate host *M. albus*; this phenomenon has been observed in other acanthocephalans (Amin 1982); and the early development of attachment organs to ensure establishment of new recruits in the gut of the definitive host (see Amin 1986, 1987 for other examples).

Omissions in the original description include accounts of the giant nuclei of the hypodermis, lemnisci, and proboscis/neck, as well as some details of the male reproductive system and hook and spine insertion. We noted that one dorsal and one ventral elongate giant hypodermal nuclei were normally present. They were rarely absent on either side. Two similarly elongate giant nuclei were also noted within the proboscis retractor muscles in the proboscis/neck area. These nuclei are rarely reported in the genus *Pallisentis* but have been recently observed in *Pallisentis* (*Brevitritospinus*) *vietnamensis* Amin, Heckmann, Ha, Luc & Doanh, 2000. Each lemniscus had one large oval giant nucleus located at the level of the posterior half of the proboscis receptacle. Wongkham & Whitfield (1999) made no reference to the two large nuclei in the wall of Saefftigen's pouch which was properly described posterior to the cement reservoir (Fig. 1B) but not "at the posterior margin of cement gland" as stated in the Abstract (Wongkham & Whitfield 1999). No reference was made to the prominent sperm duct which ran parallel to the cement gland or the large common sperm duct which ran parallel to and overlapped Saefftigen's pouch and the posterior half of the cement reservoir. Proboscis hooks had variably elevated cuticular rims that were often prominent and body spines consistently had distinct cone-shaped cuticular sleeves that left only spine tips naked.

Misinterpretation in the original description includes accounts of the proboscis hook roots, brain (cephalic ganglion), collar and trunk spines, and position of the female gonopore. Each of these characteristics has important taxonomic significance that can not be overlooked. Three aspects of proboscis hook roots need to be addressed. All hook roots extend laterally for a short distance then loop back posteriorly in a direc-



Figs. 1–3. Diagnostic features of *Pallisentis* (*P.*) *rexus*. 1. One row of proboscis hooks and roots of female. 2. Posterior part of female proboscis receptacle showing triangular brain (cephalic ganglion) and ventro-lateral nerve cord passage through indented part of proboscis receptacle. 3. Posterior end of female showing slightly subterminal position (near terminal on ventral site) of gonopore. Scale bars = 100 μm.

tion paralleling that of the blade thus forming an inverted U-shaped structure (Fig. 1). In the original description, the angle between hook and root was shown to be about 120–140° inaccurately creating an inverted open V-shaped blade-root complex (Fig. 2A). Roots were only slightly shorter than blades in all circles with a ratio of 1:1.0–1.2, 1:1.4–1.5, 1:1.3–1.4, and 1:1.1–1.2 from anterior (Fig. 1). In the original description, roots were shown to be considerably shorter than blades in all circles with an unrepresentative ratio of 1:2, 1:2, 1:2, and 1:3 from anterior (Fig. 2A). In the same figure, Wongkham & Whitfield (1999) show the roots to be simple and with rounded corners. Actually, the roots do not have rounded corners and are not all simple. Hook roots in the second circle have conspicuously long anteriorly directed manubria and those in the third circle have prominent but shorter anteriorly directed manubria (Fig. 1).

The brain was not mentioned in the orig-

Table 1.—Diagnostic characteristics of *Pallisentis* (*Pallisentis*) *rexus* adults and subadults (measurements in μm unless otherwise stated).

	Adults (Wongkham & Whitfield 1999) (30 males, 30 females)	Subadults (this paper) (15 males, 17 females)
Trunk	Elongate, cylindrical	Cylindrical, enlarged anteriorly, curved ventrad posteriorly
Giant nuclei		Thin, elongate
Hypodermal	Not given	1 (rarely 2) dorsal, 1 ventral; rarely absent
Lemniscal	Not given	1 in each lemniscus
Proboscis/neck	Not given	2 (in retractor muscles)
Proboscis roots: hooks	1: 2–3 (Fig. 2A), inverted open V-shaped	1: 1.5, inverted U-shaped
Hook insertion simple	Simple	With variably elevated cuticular rims
Hook roots	Simple	Roots of second and third hooks with manubria
Brain	Oval, in mid-posterior part of proboscis receptacle (Fig. 1A); a misinterpretation of giant nucleus of lemniscus	Triangular, in indented ventro-posterior part of proboscis receptacle
Spines	"Most" with "broader roots"	Broadest at base, with cone-shaped cuticular sleeves
Collar	"Spear-shaped," split anteriorly (Fig. 2B)	Broad triangular, split longitudinally separated anteriorly, but tips fused
Trunk	"Spear-shaped," not split (Fig. 2C, D)	Thin triangular, split distally
Males		
Trunk (mm)	1.9–12.5 (6.02) by 0.20–0.55 (0.39)*	3.56–5.20 (4.97) by 0.29–0.49 (0.38)
Proboscis	100–150 (120) by 90–230 (200)	112–145 (130) by 175–220 (203)
First circle hooks	60–79 (68); 12 hooks	70–82 (77); 12 hooks
Second circle hooks	49–66 (57); 12 hooks	54–67 (61); 12 hooks
Third circle hooks	36–50 (43); 12 hooks	35–47 (42); 12 hooks
Fourth circle hooks	24–33 (28); 12 hooks	27–34 (31); 12 hooks
Proboscis receptacle	250–1,500 (550) by 90–220 (160)	572–738 (664) by 177–208 (200)
Lemniscus		
Long (mm)	0.15–3.05 (1.21) by 0.02–0.07 (0.05)	1.55–2.60 (2.19) by 0.05–0.07 (0.06)
Short	0.12–2.87 (1.02) by 0.02–0.07 (0.05)	1.41–2.24 (1.78) by 0.04–0.07 (0.06)
Collar spines		
Circles/no. per circle	12–17/6–18	14–16 (14.8)/7–20 (13.7)
Length	1–40 (24)	20–28 (23) (ant.); 20–28 (26) (post.)

Table 1.—Continued.

	Adults (Wongkham & Whitfield 1999) (30 males, 30 females)	Subadults (this paper) (15 males, 17 females)
Trunk spines	May reach anterior testis	May reach posterior testis
Circles/no. per circle	17–32/2–14	17–32 (25.4)/6–12 (ant.), 1–3 (post.)
Length	12–50 (28)	22–30 (26) (ant.); 20–25 (23) (post.)
Anterior testis	120–1,250 (500) by 40–220 (120)	347–572 (465) by 73–125 (100)
Posterior testis	110–1,140 (500) by 40–260 (110)	343–541 (433) by 83–135 (114)
Cement gland	140–1,600 (740) by 20–220 (100)	541–811 (671) by 62–104 (88)
No. nuclei	16–25	19–30
Females		
Trunk (mm)	2.3–33.0 (12.07) by 0.02–0.67 (0.41)	5.41–8.94 (7.57) by 0.28–0.48 (0.41)
Proboscis	120–160 (140) by 90–270 (200)	137–175 (155) by 183–240 (219)
First circle hooks	66–90 (78); 12 hooks	75–93 (83); 12 hooks
Second circle hooks	58–74 (66); 12 hooks	62–75 (69); 12 hooks
Third circle hooks	40–56 (48); 12 hooks	42–55 (49); 12 hooks
Fourth circle hooks	24–40 (32); 12 hooks	30–39 (34); 12 hooks
Proboscis receptacle	220–980 (590) by 110–240 (170)	520–801 (681) by 156–249 (206)
Lemniscus		
Long (mm)	0.48–4.05 (1.71) by 0.03–0.08 (0.06)	2.45–3.05 (2.70) by 0.05–0.06 (0.06)
Short (mm)	0.40–3.92 (1.41) by 0.03–0.08 (0.06)	1.73–2.55 (2.20) by 0.04–0.06 (0.06)
Collar spines		
Circles/no. per circle	12–19/8–18	12–17 (14.3)/2–20 (14.3)
Length	12–43 (29)	20–29 (22) (ant.); 25–30 (28) (post.)
Trunk spines		
Circles/no. per circle	29–59/9–17	41–63 (47.8)/5–14 (ant.), 1–3 (post.)
Length	12–64 (34)	25–31 (28) (ant.); 18–27 (21) (post.)
Gonopore	''Slightly subterminal''; ventral (Fig. 1C)	Slightly subterminal; not ventral
Eggs	95–116 (107) by 36–45 (42)	Not available

* Range (mean). Wongkham & Whitfield (1999) did not provide a separate measurement for trunk length but used ''total body length'' which also included the length of ''elevated proboscis.''

inal description but was drawn as an oval structure at the center of posterior part of the proboscis receptacle (Fig. 1A). Clearly this is a misinterpretation of the lemniscal giant nucleus which usually overlaps the proboscis receptacle in the same location. The brain is actually triangular in shape and is situated near the posterior part of the proboscis receptacle on the ventral side where the passage of the ventro-lateral nerve creates an indentation in its wall. No corresponding dorso-lateral nerve was observed. Only two other major nerves are evident, the anterior median and posterior median nerves (Fig. 2).

Collar and trunk spines were longest in the middle of the trunk then decreased in size towards both extremities. In males, anterior collar spines were 20–28 (23) long increasing to 20–28 (26) long in posterior most circle and anterior trunk spines were 20–30 (26) long decreasing to 20–25 (23) long in posteriormost circles. Corresponding measurements in females are 20–29 (22), 25–30 (28), 25–31 (28), and 18–27 (21), in the same order. All collar and trunk spines have cuticular cone-shaped sleeves encircling the whole spines except for their distal tip. The morphology of spines is revised as follows. Collar spines triangular, broadest at base, split longitudinally, fused at tips but separated into 2 or 3 branches anteriorly. Trunk spines are also triangular in shape but are split only posteriorly.

Some measurements in the original descriptions (Table 1) relating to some organs are questioned: maximum length of proboscis receptacle in males; minimum length of long and short lemnisci in males; minimum length of collar spines in males; minimum trunk width in females (at widest point); minimum proboscis width in both males and females; See Table 1 for details. One of these proboscis measurements is in error since the proboscis is consistently markedly wider than long.

The position of the female gonopore was described as "slightly subterminal" but illustrated in Fig. 1C of Wongkham & Whitfield (1999) in a completely ventral position some distance anterior to the posterior tip of the trunk. In our subadults, it was slightly subterminal (Fig. 3). In paratypes, it was in the same position as observed in our specimens and not as illustrated in Fig. 1C of Wongkham & Whitfield (1999).

Conclusions

The taxonomic implications of inadequacies in the original description of *P.* (*P.*) *rexus* are noted. The description of that species as revised in the present report is considered accurate and complete. It increases the number of species of the genus to 30. Twenty-six valid species were reviewed and keyed by Amin et al. (2000). The remaining three species are *Pallisentis chongqingensis* Liu & Zhang, 1993, *P. fotedari* Gupta & Sinha, 1991, and *P. jagani* Koul, Raina, Bambroo & Koul, 1991. The first of these three species belongs in the subgenus *Pallisentis* Van Cleave, 1928 and the latter two in the subgenus *Brevitritospinus* Amin, Heckmann, Ha, Luc & Doanh, 2000 according to Amin et al. (2000).

While Wongkham & Whitfield (1999) were correct in stating that the "invariable 12 proboscis hooks per circle . . . is the primary basis for considering the acanthocephalan under study as a new species," we add two other unique characteristics that distinguish *P.* (*P.*) *rexus* from all other species of the genus. These are the unique shape and location of the brain and the split nature of collar and trunk spines. The anatomy of proboscis hook roots is also unusual for the genus *Pallisentis* and represents an important distinguishing characteristic.

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